The Detector R&D Program at Argonne National Laboratory

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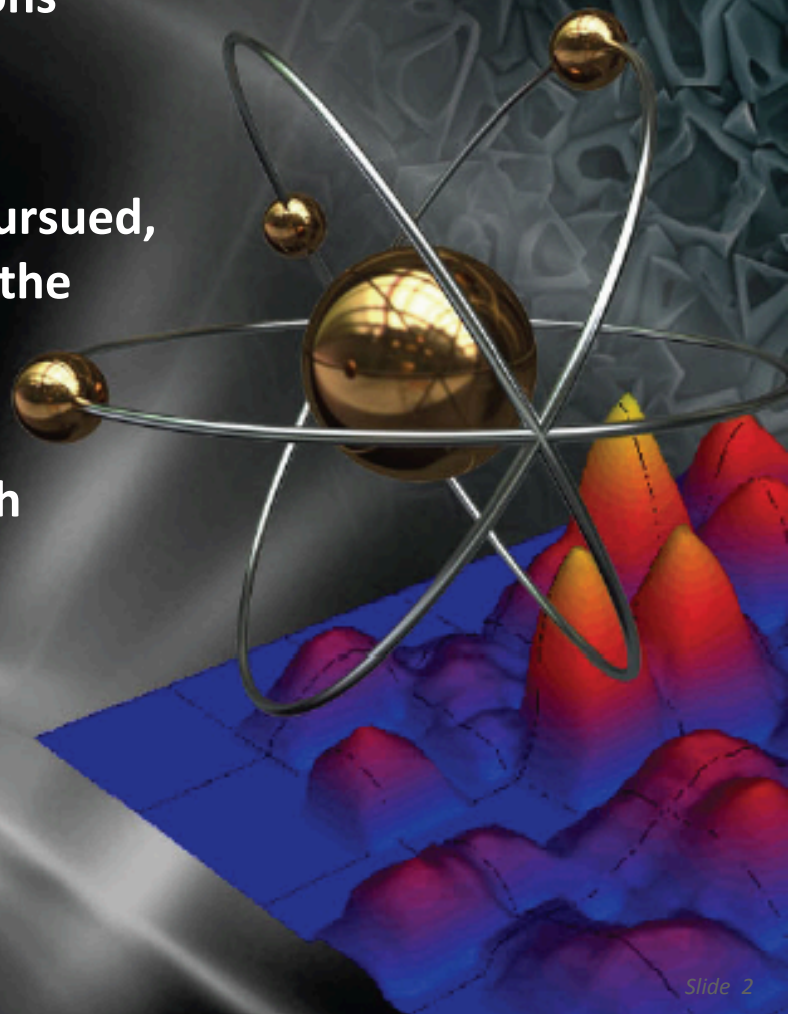
Our Unifying Goal

To develop instrumentation that *enables, and is unique*

Enable answering the fundamental questions in High Energy Physics

Unique methodologies and technologies pursued, leveraging the multi-disciplinary nature of the laboratory

In the context of a very dynamic world with rapidly changing priorities



LDRD Program

Project Title	PI	FY06	FY07	FY08	FY09	FY10	FY11	FY12
Pico-Second Timing	Byrum	110	110	70				
Silicon PM	Drake		100	125				
Dark Energy Survey	Kuhlman		330	200	130			
COGENT	DeLurgio		66	80				
Astrophysics	Byrum			300	270	408		
Transition Edge Sensors	Novosad		610	800	600			
Computational Cosmology	Kuhlman			130				
Low Mass Technologies	Underwood					205	186	180
Photo-Cathode Growth	Demarteau						200	153
Towards the Exascale Sky	Habib						351	1,014
Techniques for Large Instrumentation	Djurcic						180	180

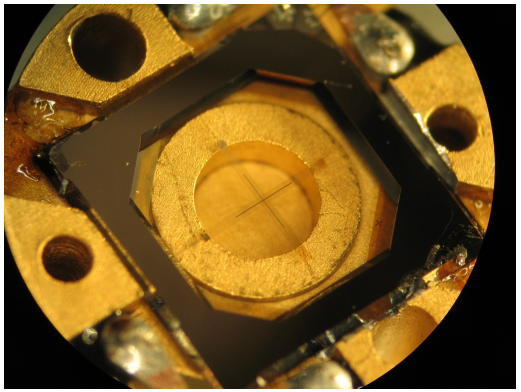
- Successfully used LDRD grants to establish base funding
- Some quite successful and jumped directly from LDRD to project funding

Project Alignment

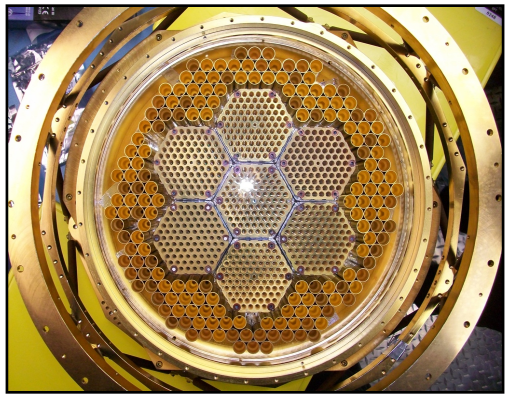
Project	"Unique"	"Enable"
TES	Combine superconducting materials science expertise with HEP mission goals	Study of the dawn of time; composition of universe
Optical	Alternate robust technology for data readout, work with industry; study new materials for opto-photonics	Full exploitation of energy and intensity frontier data
Trigger	Next generation CAM based trigger; build new capability based on 3D technology following industry lead	Full exploitation of energy frontier data; pattern recognition capability
LAPPD	Advances in materials science integrated in new methodology; close collaboration with industry from start	H_2O Č-detectors, collider TOF, collider vertexing, rare K-decays, PID, TOF-PET, ...
DHCAL	Ultra-fine segmentation with integrated readout using alternate technology; RPC expertise	Improved jet E-resolution, imaging calorimetry

- All tackle fundamental limitations in current state of instrumentation to advance science

Transition Edge Sensors: The Last Three Years

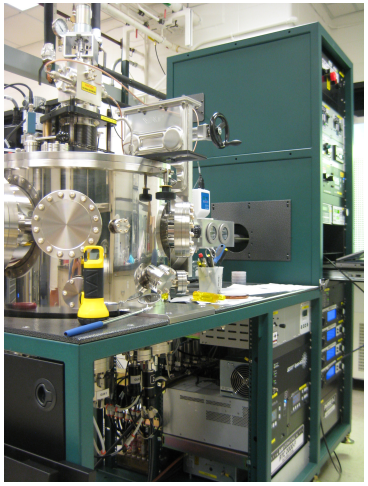


Superconducting TES



Focal Plane

Taking Data on SPTpol

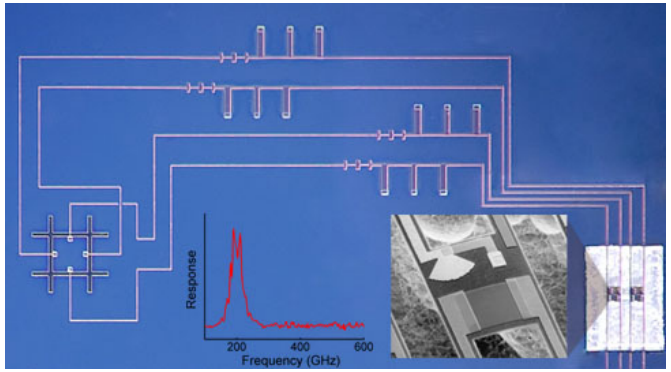


MSD

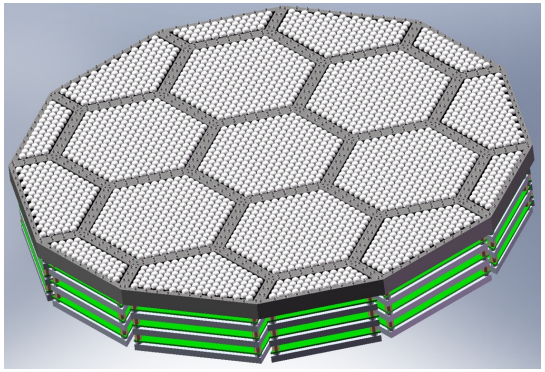
HEP

CNM

Transition Edge Sensors: The Next Three Years



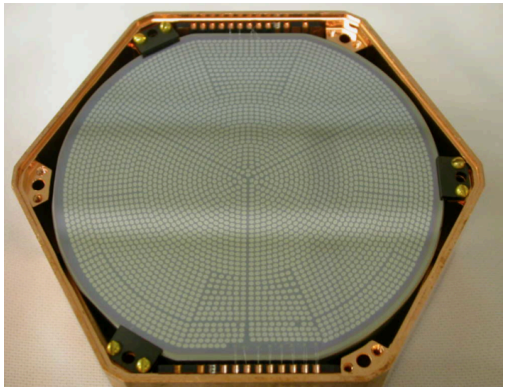
Multichroic TES



3rd Generation Focal Plane

Target: Fundamental Science

- Dark Energy, Dark Matter
- Number of Neutrinos and their mass
- Inflation
- Structure evolution



Dark Matter Detectors

Multi-chroic, multiplexed TES Array Technology

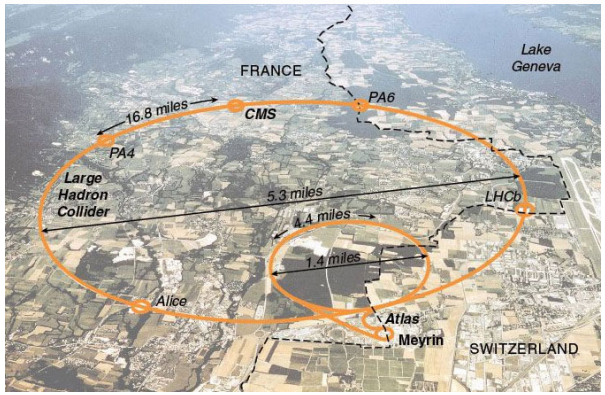
Office of Science
U.S. Department of Energy

National Nuclear Security Administration

Optical Readout

- The Google Fiber Project aims to deploy a 1 Gb/s fiber network in Kansas City using commercial products

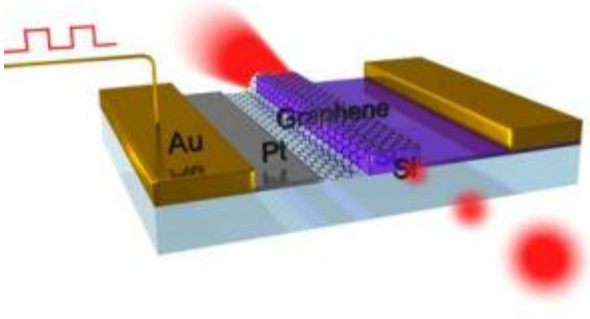
- The Argonne Optical Modulator Project aims to deploy ***radiation hard,*** >10 Gb/s optical links, for all of the LHC experiments replacing VCSELs based on commercial products



- Collaboration with company to develop technology while at the same time transferring unique expertise to industry

LUXTERA

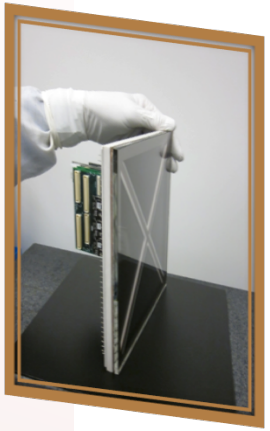
- 1 Gb/s, 10 Gb/s, ... 500 Gb/s ?
  Study of novel materials with CNM, CNM at Purdue and MSD to vastly enhance throughput and explore new charged particle detection techniques



LAPPD: The First Three Years

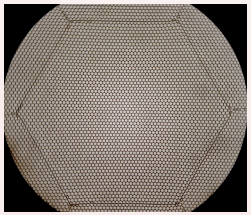
R&D 100 Award

SBIR/STTR
Incom ($3M)

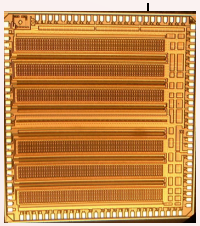


First Full
Device

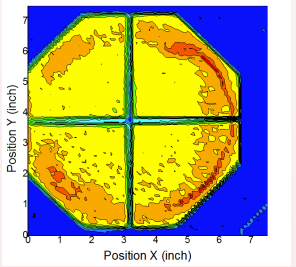
ALD Technology
Licensed



MCP Technology
select



PSEC4, fastest
sampling chip,
17 GHz



7” Photocathode

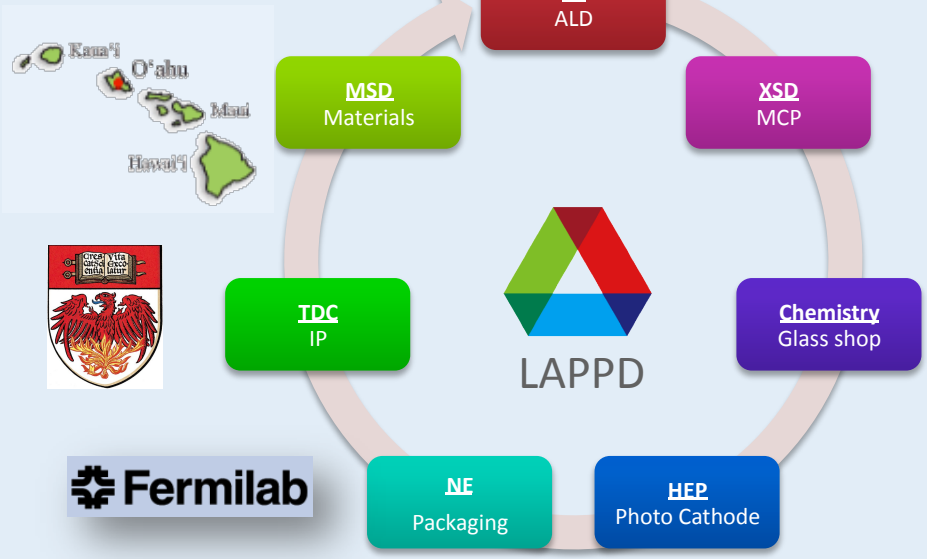
t=0 t=1yr t=2yr t=3yr

time

Partnerships in LAPPD

2012 R&D 100 The Oscars of Innovation 50th ANNIVERSARY

Primary Developer	2012 R&D 100 Winning Technology	Co-developers / Contributers
Argonne National Laboratory	Large Area Micro-channel Plates	Incom, Inc.; Berkeley Space Sciences Lab



2012 R&D 100 Award made possible through tight collaboration between 7 divisions at Argonne, National Labs, Universities and Industry

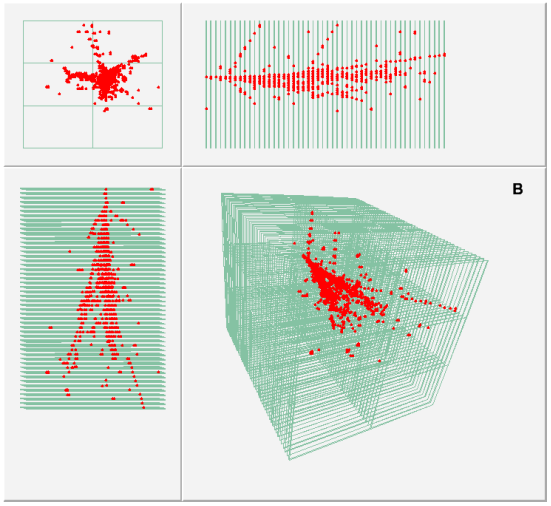
Enabled by DOE-HEP

Three patents;
One license for ALD process

http://www.rdmag.com/Awards/RD-100-Awards/2012/06/R-D-100-2012-Winners-Overview/

Digital Hadron Calorimeter

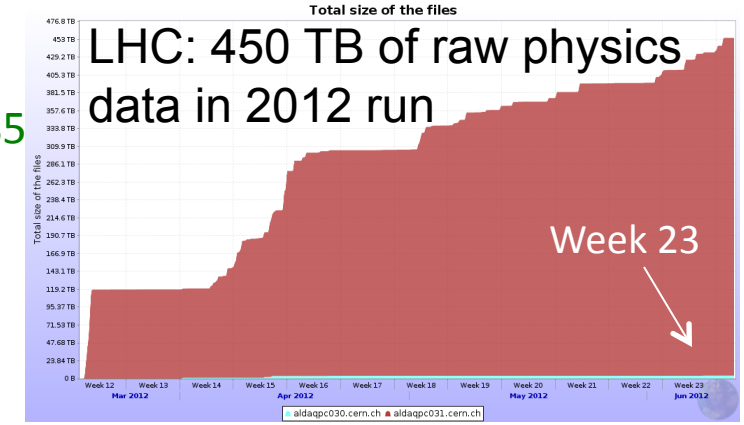
- Conceived within the context of the ILC, aimed at providing the most accurate measurements of hadronic showers
  - One of the most successful technologies of CALICE to date
  - Most finely segmented calorimeter (1cm^2 pads)
  - Embedded electronics
  - Many successful testbeam campaigns Fe/W



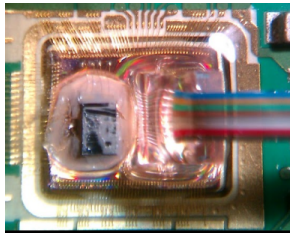
- Use as tool for the user community: “monitor” for absorption calorimeters (THCAL, g-2, CMS forward calorimetry)
- Test bed for new technologies: low resistivity glass
- Future projects: ILC in Japan, Auger, FAIR, ORKA, LHC, ...

Trigger

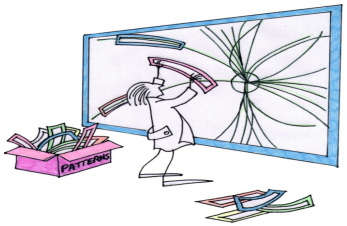
- "No one will need more than 637 kilobytes of memory for a personal computer." Bill Gates, 1985
- Granularity of detectors and data volumes will continue to increase tremendously



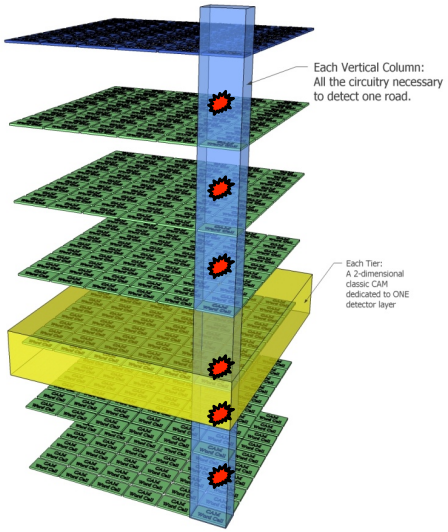
- Need to:
  - Ship data volume fast
  - Process data near instantaneously



- Addressed through:
  - Modulator development
    - Large amounts of data
  - FTK ATCA based development
    - Instantaneous processing based on modern communications standard
  - 3D Track Trigger
    - Getting ready for the next order of magnitude



Road

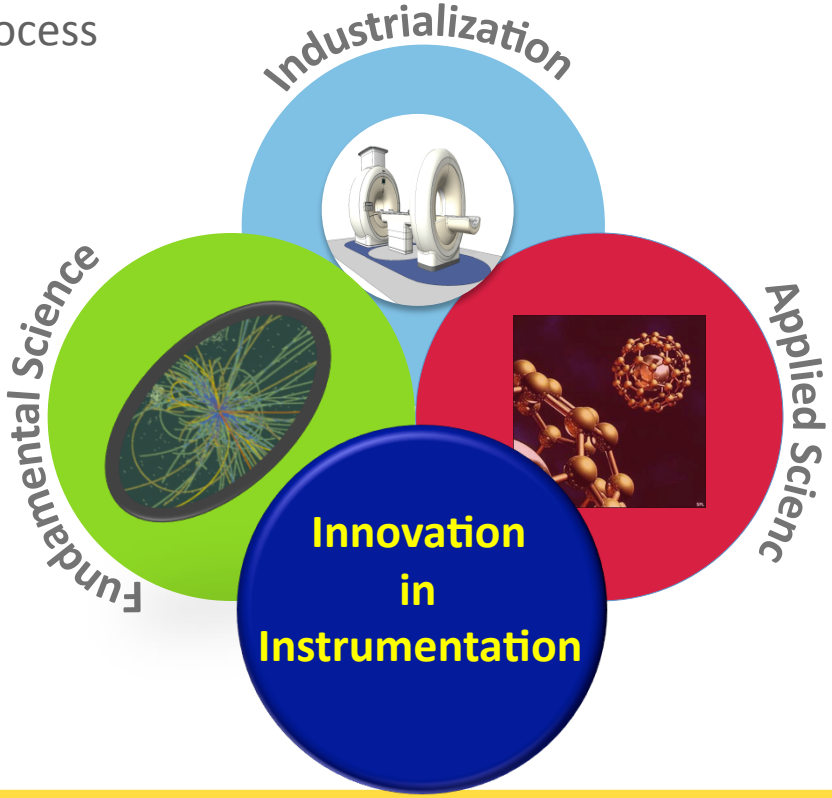


Interconnectedness

- Cycle of fundamental science – applied science – industrialization – education; very non-linear process

"Thermodynamics owes more to the steam engine than the steam engine owes to science".

-- George Porter



"One day sir, you may tax it."
-- Michael Faraday (1850)

On the practical value of electricity

Hard X-Ray Sciences | Materials Science | Nanoscale Materials | High Energy Physics | Chemistry | Nuclear Engineering | Leadership Computing

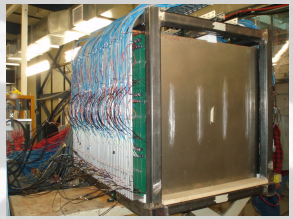
Delivery and Impact

Supported projects are brought to fruition to enable the science:

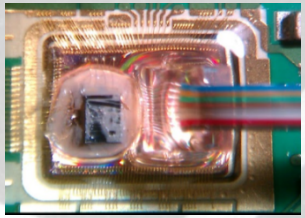
- **Topological trigger, funded by LDRD, now taking data on VERITAS telescope**

- **Transition Edge Sensor development, initiated by LDRD, now taking data on the South Pole**

- **Digital Hadron Calorimeter, initiated for ILC, now completed (and used by CLIC project)**



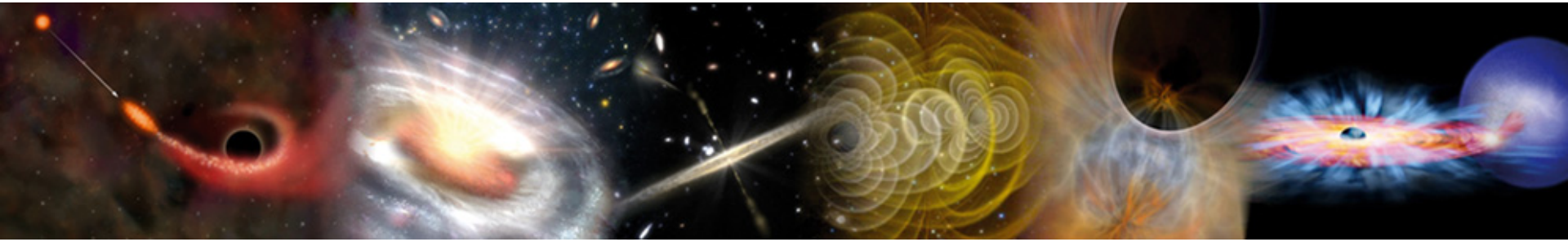
- **Optical Modulators, funded by LDRD, being incorporated in ATLAS TileCal**



- **Micro-Channel Plate functionalized through Atomic Layer Deposition: RD100 award**

Summary

- Targeted multi-disciplinary detector development program
- Program is focused, science driven, internally reviewed, to advance experimental capabilities using unique methodologies and technologies
- A key to current and future success is to embrace advances in other sciences and collaborate with other science disciplines through a bi-directionally process



Delivery and Impact

- **LAPPD: from a bold idea three years ago to ....**

... and deliver